

Chapter 0.  
**Course Plan**

Danupon Nanongkai


**KTH, Sweden**

## Goal

Lower bounds for dynamic problems  
based on various conjectures.

# Fine-grained Complexity & Static Problems


## The real world and hard problems




I've got data. I want to solve this algorithmic problem but I'm stuck!

Ok, thanks, I feel better that none of my attempts worked. I'll use some heuristics.

I'm sorry, this problem is NP-hard. A fast algorithm for it would resolve a hard problem in CS/math.



## The real world and easy problems




I've got data. I want to solve this algorithmic problem but I'm stuck!

But my data size  $n$  is huge! Don't you have a faster algorithm?

Great news! Your problem is in P. Here's an  $O(n^2)$  time algorithm!

Uhm, I don't know... This is already theoretically fast... For some reason I can't come up with a faster algorithm for it right now...



# Fine-grained Complexity & **Dynamic** Problems



I want to analyze this **evolving data** but I'm stuck.

There is a lower bound of  $\Omega(\log^2 n)$  in cell-probe



But  $O(\log^5 n)$  will be good enough

Sorry, we don't know how to prove big cell-probe lower bounds, and there is no such thing like NP-hardness ...

# Rough Plan

1. Introduction to dynamic algorithms
  - Update & Query Time
  - Incremental/Decremental Algorithms
  - Amortization & Empty-start assumption
  - Randomization & Oblivious-adversary assumption
2. Lower bounds based on the OMv conjecture
3. Other conjectures
  - SETH, OV, dynamic OV, BMM, 3SUM, APSP, Multiphase, etc.

## Optional:

- Unconditional lower bounds
- Hardness of FPT-approximation (GapETH-,  $W[1]$ -hardness, etc.)

# Questions?

## Acknowledgements:



Sayan Bhattacharya  
Warwick



Jan van den Brand  
KTH



Deeparnab Chakraborty  
Dartmouth



Sebastian Forster  
University of Salzburg



Monika Henzinger  
University of Vienna



Christian Wulff-Nilsen  
University of Copenhagen



Thatchaphol Saranurak  
KTH



This project has received funding from the *European Research Council (ERC)* under the *European Union's Horizon 2020 research and innovation programme* under grant agreement No 715672

